

judgment and leadership of the great administrator, and the intensely human qualities of Karl Compton.

It is an honor indeed to represent my associates in the American Institute of Electrical Engineers in paying tribute to this great American, Karl Compton.

Engineers and National Security

KARL T. COMPTON
FELLOW AIEE

NO ONE COULD help but be deeply appreciative of the honor of being selected as a recipient of the Hoover Medal. Few, if any, of the recipients will have had such reason as I for a feeling of humility when we compare our attempts to serve our community and nation with the high standards set by the donor of this medal, Conrad N. Lauer, and by the great American, Herbert Hoover, in whose honor the medal was named and who was its first recipient.

A few years ago I was privileged to attend a very large, informal gathering of men of all shades of opinion from all parts of the country, where Mr. Hoover was to make an address. I shall never forget the thrill of his introduction as "America's most respected and beloved citizen, Herbert Hoover," or the great applause which followed this simple but adequate statement, more eloquent than any eulogism. There are those who may not always agree with him in his political or national policies. There are no men of good will who do not respect his unswerving and unselfish and effective service to his country and to mankind. I am proud indeed to be inducted into the brotherhood of the Hoover medalists.

Pleasant as it is to give and to receive acclaim, I have no doubt but that the chief purpose and value of the Hoover Medal are to create occasions in which the spirit of unselfish service, by professional men, to their society and their country can be emphasized in the public mind. In other words, I would say that the purpose is educational and inspirational, in that the medal and the medalist are like lenses whose function is to focus attention on the basic objective.

May I say just one other thing, before turning to the topic of my address? Unlike most of the previous medalists, and unlike most of you, I am not a real bona fide engineer. Probably no licensing board would give me a permit to practice the profession. I am only an engineer by adoption, and for the associations which have made this possible I am extremely grateful. These associations, both personal and occupational, have been so much a part of my career that I cannot but feel that, in receiving this Hoover Medal, I am receiving it on behalf of some hundreds of engineers and scientists who have constituted the various teams on which I have played this game of public service, and it is

those teams which have made the achievements. I should like to mention just a few of these.

ENGINEERING ASSOCIATES

THE FIRST engineer who left a great imprint and inspiration on all my future career was Dr. W. F. Durand—close personal friend of Mr. Hoover and now Emeritus Dean of Engineering at Stanford University. I was his assistant in France during World War I. No man could have had that personal contact with him without absorbing something of his spirit of scientific honesty, engineering courage and competence, complete devotion to duty, and with it all a sensitive spirit of courtesy and sympathy. His was the basic gift of the great teacher, the unconscious ability to arouse in his associates the spirit of "go thou and do likewise."

Then, when I made my decision to cast my lot with the Massachusetts Institute of Technology, I took the plunge into an engineering environment which has been filled with stimulus and opportunity, again with the invaluable accompaniment of kindred souls as team-mates in new enterprises.

Shortly thereafter came a new opportunity, in which a number of you in this room participated. It started out as just another chore which somebody had to do. It was the program of accrediting the engineering schools of the country in order that the existing state laws for the licensing of engineers could be rationally administered. I suspect that few of us who worked on the development and introduction of this accrediting program had any wild missionary zeal for accrediting as such. At least I personally would have rather been doing other things. But the job had to be done, and it was important that it be done as well as possible. So it was undertaken under the auspices of the newly formed Engineers' Council for Professional Development. But it proved to be an exceedingly interesting undertaking and the results were satisfying. But the thing which most impresses me as I look back on that experience is the new group of personal friendships and institutional associations which grew out of this work. I mention this episode for two reasons: it was the occasion of my first close contact with this great professional society, the AIEE, and the sister engineering societies; and it illustrated the interesting point that jobs undertaken from a sense of duty, and perhaps reluctantly, very frequently pay an extra dividend of fine new friendships. One reason for this is that people who are found on such jobs are naturally unselfish, loyal to causes and ideals, good workers and co-operative. Such people make good friends.

Finally there came World War II, with its mobilization of scientists and engineers to develop and produce and use the materials and devices on which our national safety so critically depended. Here, in the close associations and in the necessity of getting results, scientists and engineers came to understand and appreciate each other as never before. They learned to work together in teams. Sometimes the distinctions between them were completely lost, because they were found doing the same things in the same way. Sometimes the distinctions between them were put to good use by appropriate division of labor. The

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engineers learned that at least some highly theoretical scientists hatched out ideas of tremendous practical importance. The scientists learned that engineers could do some things better than they could, especially when it came to getting ideas translated into physical form suitable for production and field use. To me, as to very many of you, this was a vivid experience and one which emphasized the significance of teamwork as no other experience in our history.

My reason for giving this personal slant to my introductory remarks is not only because the award of a medal has a personal interest, even though the happy recipient is far less important than the principle of the thing. These personal experiences serve to illustrate a very important factor in the problems which concern the subject announced for my address: "Engineers and National Security." But before I tackle this subject, perhaps I had better explain that it is a misnomer. When I tried to put down on paper what I had in mind, when I sent the proposed subject to President LeClair, I found that I was setting out to write a book rather than an address. So I decided not to inflict on you several years of pent-up ideas about how scientists and engineers could be better used to save the world, and started afresh on some thoughts which I hope are more appropriate and which certainly will be more briefly expressed.

PROBLEMS OF LEADERSHIP

AS I GET occasional glimpses of the efforts which are currently being made to organize and direct our nation's technological strength for the national security, there are many, many problems at many echelons. Some of these problems relate to the impacts of science on international relations and policy; some relate to military strategy; some relate to the continuing strength of our economy; some relate to the selection of priority objectives for research and development and production; some relate to the technical methods for carrying these things through to realization and use. One thing which all these problems have, as a common denominator, is that their successful handling depends entirely on the ability to find men capable of handling them.

In the experiences which I mentioned previously, in World War I, at MIT, in the surveys of the engineering schools, in World War II, the most difficult and most continually pressing problem was to find the people who were competent and available to do the jobs. The more important the situation is, the more does this problem of man power stand out as number one in time, in importance, and in difficulty.

Even before the international situation became as acute as it is at present, I had striking evidence of the persistence of this problem. Last April I attended the meetings of the National Academy of Sciences in Washington. It was my first visit to the city since I had been forced by health to resign six months earlier from the chairmanship of the Research and Development Board. I took one day off from the scientific meetings to visit the Research and Development Board's offices, dropping in to see my friends and former associates. It was an interesting and heart-

warming day, but the feature of it that made the vivid impression on me was this: without exception, when I would get up to leave one friend's office to go to another, he would say: "Can you stay for a few minutes to talk business? We need some one to handle such and such a job, and we have not been able to find a person who seems to be just right for it, and who is available. Can you give us any suggestions, or can you help us to get so-and-so made available?"

This is just one line of voluntary public service, and just one of many agencies, and the episode occurred before the Korean war had destroyed the fabric of hope and wishful thinking which had shielded us from the grim realities that are now so unmistakable. By this time the situation has changed in several respects. The emergency program now in process of activation is calling for the services of many more men. The situation is now sufficiently serious to give such service a high priority, as men try to decide what they should do, and to that extent it is now possible to command the services of men who were unavailable six months ago. But still the number-one problem is to find the men to do the jobs. I have participated in many policy and planning conferences during the last couple of months in MIT, Washington, and New York, and it is no exaggeration to say that the search for the right men to do the jobs which are clearly outlined is the major hurdle to be surmounted if these jobs are to be done effectively.

The public is prone to think that money is what gets things done. Congress passes laws to accomplish objectives, and establishes organizations on paper and appropriates funds to implement these laws. All this is necessary and proper. It gets publicity and the public feels that the job is in hand. If, later, it learns that the job, which its Congressional representatives ordered done and for which it is paying through taxes, is not proceeding satisfactorily, a great hue and cry may be raised. But back of the scenes there may very well have been the failure, in spite of strenuous search, to find the people qualified to get the job done. I have often felt sorry for the head of some governmental agency, even up to the President himself, when he has been criticized for making an ineffective appointment, and when I have known that man after man to whom the job has been offered has refused to take it.

The serious bottlenecks to American accomplishment, whether in public affairs or in private business, are not lack of funds but lack of the proper quality of man power. There is a profound difference between dollars and men. All dollars, provided they are not counterfeit, are alike and interchangeable; men are not alike and, the more important and difficult is the task for which they are needed, the less are they interchangeable. If the emergency becomes great enough, dollars can be turned out on the printing press or by equivalent means; men cannot be turned out to order, and Nature has set a delay period of a couple of decades at least before new people of economic or security usefulness could be made available, even if the order to produce an increased supply went out and were obeyed. In other words, any monetary bottleneck can be broken open if the emergency is serious enough to justify the means for doing it: however, there is absolutely noth-

ing which can be done quickly to get around a basic dearth of human talent.

KEY PEOPLE FOR KEY JOBS

BUT LET US examine more closely this question of finding key people to handle the key jobs. In reference to any given task of major importance, there appear to be three basic questions as to its leadership: (1) Do men of the necessary qualifications exist? (2) How can these men be found? (3) If found, how can they be secured? On each of these questions so much could be said and argued that I shall not even attempt the task, but I will ask you to have them in mind as I make the following general observations.

1. As I have heard the suggestions of men of scientific and engineering background for key posts in the present mobilization, it has been notable that the same names are discussed over and over again for the various positions. Their number is not large. They are generally in the same age range as were those who led in similar positions of responsibility a decade or less ago—old enough to have achieved experience and recognition and still young and vigorous enough to stand the exacting demands of a national emergency program.

2. Undoubtedly there are others who have the inherently desirable qualifications. Their discovery is the major problem. Perhaps they have not been discovered simply because they have not been engaged in similar activities, or associated with those who have been thus engaged. This in itself is a handicap not only to their identification, but also to their quick effectiveness if they were to be put on the job.

3. Of course, there really are a lot of people who would take these jobs. Many have actually applied for some of them, or otherwise asked to be used. Probably some of these people would do very well. But the real responsibility for filling the positions of high importance is to be as sure as is humanly possible that the person put into the position be qualified to handle it effectively. This takes more than willingness. It takes qualities of training and experience, built into native character, and previously demonstrated.

4. Census lists, rosters, psychological tests, and other guides for personnel selection have useful functions, but such values are more pertinent to the availability and selection of large groups than to the selection of individuals for key posts. The most effective organizations during World War II were built up by first selecting carefully the top leaders, letting them recruit the next level from among their professional acquaintances, and letting these in turn fan out to complete the organization. No punch card lists or file of information can compete with judgment based on personal knowledge in the recruitment of a coherent, hard-hitting team.

From these comments, you will gather that I am convinced that the creation of a new organization, to be effective, must be a highly personalized affair. The provision of the top echelons of leadership is not a process

that can be dealt with in terms of broad categories or rules. The requirements are too sensitive to be handled effectively on any such basis. It is only at the so-called lower levels, sometimes improperly called the "working levels," that men become interchangeable units within large categories, and that they can be usefully selected or assigned on the basis of descriptions and job specifications.

CHANCES FOR PROMISING YOUNG MEN

WHAT, THEN, can we do to secure the desired leadership beyond hunting for it? At least one thing we can do in a manner which proved extraordinarily fruitful during the emergency of World War II. This is to give promising young men the chance to develop and demonstrate the desired qualities. It is a very striking fact that so many of the men who are today recognized as having the qualities of scientific leadership and engineering administration are young men who were "discovered" and who discovered themselves through having been thrown into positions of responsibility in the exigencies of World War II, and who otherwise might have remained undeveloped and undiscovered.

As a positive suggestion, therefore, I would advocate a conscious effort to find promising young men and try them out in jobs of increasing responsibility as they show possibility of discharging it. This is a process of both education and selection which is a regular policy in many forward-looking companies. It is not a policy in all, and in academic circles has generally had to await what we call "openings." Can we, in our various organizations, not do more than we have been doing to develop and identify leadership talent? I am sure we can. This may turn out to be far more significant in the final outcome of our present national emergency than the much more publicized handling of selective service or draft.

While such a policy is justified in peacetime, it is especially important in times of emergency, like the present, when many new activities have to be started or expanded. I have often thought of one aspect which has been a natural and, on the whole, an unfortunate trend after a war. The war closes with a peak number of experts of various types who have demonstrated unusual value to the war effort. In this respect we emerge from the war strong. But the tendency is to continue to depend on these men overlong for leadership in their fields of interest to national security. After a few years they have become too old, or too out of touch with the younger men who are coming along as the active contributors in their fields. To help overcome this tendency toward obsolescent leadership in the field of military technological developments, for example, the Research and Development Board under Doctor Bush's leadership established the policy of limited terms of service on its various technical committees. The membership of these committees started out almost completely composed of men who had been prominent in their respective fields during the war, but the plan called for a gradual replacement with new and usually younger talent, so that new generations would gradually become acquainted with the problems and be tested as to performance.

Such a plan is certainly basically sound. It has worked

fairly well, although there have been some complications which have nothing to do with this factor in the situation. But even in this specialized and highly organized area, and in spite of its professional interest, it has still proved difficult to get the desired personnel.

DETERRENTS TO ACCEPTING JOBS

AN ENTIRE additional lecture, and more, might be devoted to the question: "What deters men from accepting jobs with government agencies, and which of the deterrents might be removed by reasonable changes in the conditions of employment?" In times of great emergency the force of these deterrents is often overcome by the urge to render service. I shall not try to discuss this aspect of the problem, except in one rather philosophical aspect about which I have been thinking recently, along the following lines.

Probably all of us have felt a very significant difference in our attitude toward our "duty" in the past five years as distinguished from our attitude during World War II. Then every good man and true had to ask himself only one question when called upon to make a decision regarding his course of action. This question was: "Is this the activity open to me which enables me to make my most useful contribution toward the winning of the war?" Since that time, however, the issues on which individual decisions are based have usually been far less clear-cut, and the decisions correspondingly more difficult. For example, long-term versus short-term issues; relative weight of responsibility to various good causes, including that to one's own family, things of that sort. Here, I think, is one of the basic problems facing our country, and one which must be realized and dealt with constructively if we are to maintain ourselves against the threats from within and without against the "American Way of Life" which we prize so highly.

In conditions of extreme emergency or peril, single-mindedness of purpose is automatic and is the pattern for survival. To a starving man, food is the overpowering objective; to a drowning man, air; to a man in a burning building, escape. To a community struck by hurricane or flood, salvage and relief become the immediate concerns. To a nation threatened with conquest, defense for survival unites all classes and political groups. By such concentration on a single basic objective, the probability of gaining this objective is maximized.

But in our complex peacetime "American Way of Life" there are a multitude of legitimate objectives, each commanding the concern and allegiance of large segments of our population. The labor movement, education, religion, various aspects of social security or of social service, new business enterprise, objectives of political groups, industrial production, community planning and development, and a host of other interests all illustrate what I am referring to. In addition to such broad objectives, every person has his own legitimate ambitions and career and the welfare of his family to consider. When all these things are added together we realize why it is difficult for us to react quickly and effectively when a new emergency arises.

It is as though we were members of a football team, and our objective was to tackle the opponent. Every one of our current interests is running interference for that opponent. Only if we can crash through this interference can we hope to make the tackle.

In this respect, we are at a disadvantage with the Communists. They have a very simple formula: "Smash the capitalistic imperialists; then the world is ours." They make this simple formula stick because of two factors: their leaders keep repeating it until it registers with something like hypnotic effect; furthermore, their people have such a relatively simple life, being largely ignorant and underprivileged people of the masses, that there is not so much competition among objectives. Their leaders have to crash through relatively little interference to raise, for example, an army of Chinese "volunteers" to drive the capitalistic imperialists out of Korea.

A PARADOX

HENCE WE HAVE an apparent paradox: the very high state of our civilization, which we describe as the "American Way of Life" and which is characterized by initiative, specialization, education, social responsibility, and high standard of living, carries with it a sort of interference or inertia which prevents us from reacting as wholeheartedly and quickly as we might otherwise do in an emergency. There is a conflict of interest, and this conflict is often compounded with wishful thinking. I believe that these are some of the factors which induced our overprecipitate demobilization after World War II, which deterred us from adopting a policy of universal military training while there was yet time, which have made us so slow to accept the reality of the mounting program of Russian aggression and to take effective measures against this aggression.

Apparently our situation has to become desperate before we begin to realize that it is dangerous. Only then are we willing to subordinate interests of lower priority to those more directly related to the basic issues of survival—at least, the survival of the kind of a world that we have helped to create and hope to enjoy.

Let me give you a current illustration. A few weeks ago a group of industrial and academic research administrators was called together for an informal discussion of the increased military research and development budgets proposed as part of the plan for meeting the threats of a widening war. It was anticipated that this group would consider that the upper limit on what the Department of Defense could spend advantageously for such purposes would be determined by the available numbers of properly trained scientists and engineers, and that the draft and reserve officer policies would be topics of primary concern in the discussion. These topics were actually given considerable weight, but not nearly as much weight as was given to the extent to which our nation, our government, and even our Department of Defense would curtail, postpone, or stop an enormous lot of technical activities which, however desirable, have no high priority bearing on our ability to meet the present emergency. This was posed as the most basic consideration limiting our ability to handle

the high priority research and development programs right now.

Most of what I have said this afternoon could have fitted a somewhat different title, such, for example, as "Problems of Leadership and Decision in the National Emergency." However, I have left the title in its original form, "Engineers and National Security," because the background from which my thoughts come is that of administration of scientific and engineering activities, and because engineers are being called upon to an extraordinary degree to deal with situations in which the points which I have discussed are important, and because engineers by their very training and habits of thought are unusually well able to appreciate and to deal with the types of problems which have been outlined here.

RECAPITULATION

IN CONCLUSION, let me recapitulate some of the things I have tried to present for your consideration. Leadership at the higher levels of responsibility is difficult to find in adequate supply. Its identification is a matter for personal judgment and not for formal specifications or rosters. It can be discovered through acquaintances formed in professional associations and through team-work in good

causes. It can be developed and discovered in the younger groups by giving them responsibility, and one of the effective ways for the older generation to build up our national technological strength is to pass the responsibilities on to the younger generation as fast as they can shoulder them. Our complex life is so rich in good objectives that there are very difficult conflicts of legitimate interest when a man or an organization is asked to take on a new job for the national security, and the decision for the new job may only be compelling when the emergency becomes very serious.

As engineers, whose professional job and pride is to get things done, these problems and situations pose challenges which the engineering mind is well adapted to tackle effectively.

I am grateful for the honor of the Hoover Medal. I am appreciative of your patience as I have outlined a few of the thoughts which have been running through my mind as I have seen some of the efforts to increase our national security through work of the type which scientists and engineers are uniquely qualified to handle. I am proud to be, even by adoption, a member of the American Institute of Electrical Engineers, whose members play so important a role in our peacetime economy and in our security against disastrous aggression.

New Microfilm Recorder Controlled Electrically

A new microfilm recorder has been designed by Bell and Howell Company, Chicago, Ill., which photographs on 16-millimeter film important papers which are needed for records. The recorder automatically takes care of lens opening and shutter speed. Lighting and film rating are perfect, so the operator does not need to worry about them. Keeping the electricity under control is handled by a device made by the Sola Electric Company, also of Chicago.



Key to the success of the apparatus is synchronizing the camera's shutter action with the movement of items to be photographed. This is handled electrically. The system has three elements which must be in perfect co-ordination. They are: the motor, which revolves a roller over which the documents pass; a light which illuminates the items being photographed; and an electric clutch, which synchronizes camera speed with the speed of the documents passing through the recorder, and insures that each one is opposite the lens at the moment it is photographed.

Because voltage entering the machine is subject to irregularities, a constant-voltage transformer designed and produced by Sola has been built into the set so that variations of line voltage between 95 and 130 volts have no effect on the equipment's operation.

The microfilm recorder is incorporated in a desk (shown at left) with the automatic camera attached to one side. The operator places a pile of papers in the automatic feed, sets a few switches, and the recorder takes over. The papers pass over the spinning roller and drop into a container below. When they are opposite the camera, it takes simultaneous pictures of each side, using a pair of mirrors.

Photos are taken on a 100-foot roll of 16-millimeter film. Front and back pictures of 400 checks can be taken in one minute. The recorder can photograph paper up to 9 1/2 inches wide with the automatic feed, and 11 inches with hand feed. Pictures can be scanned later with an illuminated viewer, which enlarges them up to life size.